VITA 74 (VNX) Briefing

Concepts for VITA 74.4 (SpaceVNX) CubeSAT Applications

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VNX Abstract

SWaP & Modularity

Extending VPX Concepts Into Smaller Scale Using VNX

- Reducing size, weight and power consumption of rugged embedded computer systems, while at the same time pushing computing and I/O performance to ever higher levels has been the “holy grail” of embedded electronic design for many years.

- Price pressure and the need to shorten the “time to market” of new technology calls for modularity and a maximum of reuse when designing a new system.
  - Industry standards such as VPX and VNX help to achieve this.
  - VPX is current “mainstream” architecture of rugged embedded systems designs.

- By extending the same concepts that made VPX successful, into a still smaller form factor, VNX makes modularity accessible in areas which were up-to-now dominated by custom designs.

What is VNX

- VNX is a standard for plug-in modules
  - ANSI / VITA 74.0 (ANSI Publication in 4Q17)
  - Compute, Processing, Sensors, Memory and I/O
- VNX was designed from the ground up to be inherently rugged and conduction cooled
- VNX was designed for Space, Weight and Power (SWaP) critical applications
- VNX is designed to be similarly architected to VPX systems, but at a smaller size, lower power, and lower cost
- VNX is a **Down-Scaled Derivative** of VPX, VITA 46 & ANSI / VITA 65

The Story Behind VNX

- **VNX is a standards based, small form factor, ecosystem and infrastructure**
  - VITA-74 Technical Committee was established by VITA Standards Organization (VSO) in early 2010 and VITA VNX Marketing Alliance was established in 2014.
  - The VITA-74 Committee has significant involvement from several merchant board manufacturers, system integrators, and defense primes
  - **The standard has been approved by VITA and is in final ANSI Formatting Process**

- **VNX used existing standards to reduce technical risk and schedule**
  - VITA-46 VPX and ANSI/VITA-65 Open VPX topology and pin functionality
  - VITA-57 FMC connector
  - Other Mezzanine Standards such as PICMG COM Express Mini SBC

- **VNX committee provides reference chassis design in the standard**
  - 12.5mm and 19mm Modules
  - 4-Slot conduction cooled chassis and backplane
  - **The Reference Design seems to be suitably adaptable for 1U CubeSAT design**

They all got together……

Participating committee members

* Chair

Trident infosol — Creating Deployable Solutions

samtec

THEMIS

NAVAIR

Acromag — THE LEADER IN INDUSTRIAL I/O

REFLEXPHOTONICS™

ELMA — Your Solution Partner

LOCKHEED MARTIN

MERCURY SYSTEMS

VITA — Open Standards, Open Markets

molex®

WAVETHERM

Observing committee members

CURTISS-WRIGHT

Other companies involved

CSI — COLORADO ENGINEERING, Inc.

ALPHI TECHNOLOGY CORPORATION

PENTEK — Setting the Standard for Digital Signal Processing

VECTORNAV — Embedded Navigation Solutions

Rockwell Collins

Milcots — SAFER WORLD GROUP — Rugged, Trusted

nls neuro logic systems — Military and Industrial Display Solutions

Why Mention VPX / VNX to AMSAT Community ?

- VPX is the fastest growing standard for current generation military vehicles, including satellites
  - VITA 65 – OpenVPX for Terrestrial Vehicular Use
  - A literature search will reveal wide use in many commercial and military rugged system applications
  - VITA 78 – “SpaceVPX” and “Space VPX Lite “for Satellite Use is being developed by AFRL and Industry

- VITA 74.0 – “VNX” is a scaled derivatives of their VPX cousins, and ripe for similar exploitation.
  - VITA 74.0 is only Days Away from full ANSI / VITA Publication
  - VITA 74.4 “SpaceVNX” committee is being stood-up by government and industry for “Small Satellite” applications

What are SpaceVPX's Goals

Created to bridge the VPX standards to the space market.

- SpaceVPX addresses both interoperability (as OpenVPX does) and space application needs (not in OpenVPX).
- SpaceVPX defines Payload, Switch, Controller, and Backplane module profiles to meet needs of space applications
- SpaceVPX adds features to the Utility Plane for fault tolerance
  - Point-to-point not bussed to tolerate faults: failure on module does not affect entire system.
  - Space Utility Module added to provide dual-redundant source for Utility Plane implementations.
- SpaceVPX defines use of SpaceWire for Control Plane over Ethernet (OpenVPX preferred solution).

From AFRL Briefing

AFRL Public Release – OPS-16-12225 – Distribution Statement A
"Approved for public release; distribution is unlimited

Why VITA 74 “Dot Standard” For CubeSATs ?

- Standards Based
- Provides for Interoperability
- Allows Technology Re-Use
- Encourages Technology Insertion for Evolution & Upgrades
- Designed from the beginning for MIL Rugged Environments
- Higher reliability than other COTS adaptations such as PC/104
- Seems to be tailor made for CubeSAT applications

VNX Module Standards

12.5 mm Module

- Basecard + MiniPCIe
- 200-Pin Connector
- 75mm (L) X 89mm (W) X 12.5mm (H)
- Applications
  - SBC
  - I/O Carrier
  - GPS / IMU / SAASM
  - Storage & Memory

19 mm Module

- Basecard + Processor Mezzanine
- 400-Pin Connector
- 75mm (L) X 89mm (W) X 19mm (H)
- Applications
  - SBC / FPGA / SDR
  - RF Repeater
  - Complex I/O

CubeSAT Chassis Strategy

- Reference platform was designed from the beginning to allow it to be a platform for 1U CubeSAT designs
- Scalable to accommodate 1U or larger satellites
- Conduction Cooled & MIL Spec

1U Size Reference Platform

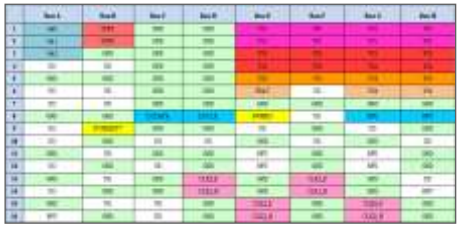
MIL Aircraft Platform

VNX Backplane Connector

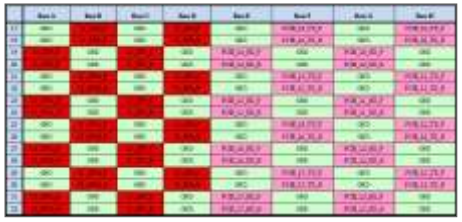
- Samtec SEARAY Series
  - Qualified in VITA 57 FPGA Mezzanine Card (FMC) standard
  - High Density 4 or 8 rows (200 or 400 pins) with 1.27 mm pitch
  - High Speed to 11 Gbps @ 3 dB loss
  - Suitable for PCIe Gen2, Gen3 and beyond
  - Straight or Right Angle
  - BGA or Press Fit

- Connector Partitioning similar to VPX
  - S0 Utility Plane
  - S1 Fabric
  - S2 User I/O

S0

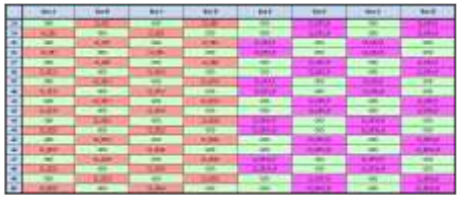


S1



- Enhanced connector location and ESD protection
  - Optional **Keyed Locator**
  - Optical & RF Connector Options being developed

S2

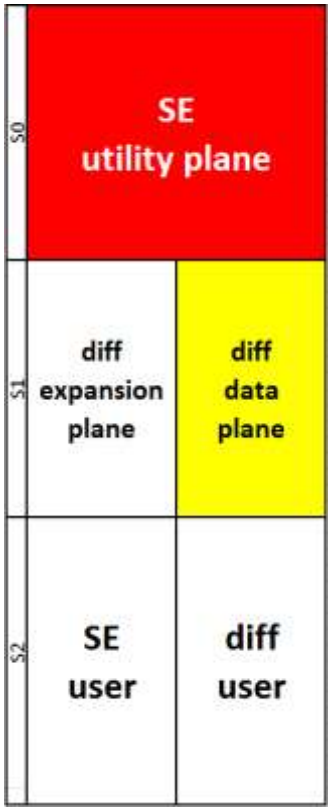


Backplane: VNX Vs. VPX

	Row A	Row B	Row C	Row D	Row E	Row F	Row G	Row H
1	GA0	VSBY	GND	GND	VS1	VS1	VS1	VS1
2	GA1	VSBY	GND	GND	VS1	VS1	VS1	VS1
3	GA2	GND	GND	GND	VS2	VS2	VS2	VS2
4	UD	UD	GND	GND	VS2	VS2	VS2	VS2
5	GND	GND	GND	GND	VS3	VS3	VS3	VS3
6	UD	UD	GND	GND	VBAT	UD	VS4	VS4
7	UD	UD	GND	GND	GND	GND	GND	GND
8	GND	GND	I2CDATA	I2CCLK	NVMRO	UD	RFU	RFU
9	UD	SYSRESET*	GND	GND	UD	GND	UD	GND
10	UD	GND	UD	UD	GND	UD	GND	UD
11	GND	UD	GND	GND	RFU	GND	RFU	GND
12	UD	GND	UD	GND	RFU	GND	RFU	GND
13	GND	UD	GND	CLK3_P	GND	CLK1_P	GND	UD
14	UD	GND	GND	CLK3_N	GND	CLK1_N	GND	RFU
15	GND	UD	UD	GND	CLK2_P	GND	CLK0_P	GND
16	RFU	GND	UD	GND	CLK2_N	GND	CLK0_N	GND

Utility plane

	Row G	Row F	Row E	Row D	Row C	Row B	Row A
1	Vs1	Vs1	Vs1	No Pad*	Vs2	Vs2	Vs2
2	Vs1	Vs1	Vs1	No Pad*	Vs2	Vs2	Vs2
3	Vs3	Vs3	Vs3	No Pad*	Vs3	Vs3	Vs3
4	SM2	SM3	GND	-12V_Aux	GND	SYSRESET*	NVMRO
5	GAP*	GA4*	GND	3.3V_Aux	GND	SM0	SM1
6	GA3*	GA2*	GND	+12V_Aux	GND	GA1*	GA0*
7	TCK	GND	TDO	TDI	GND	TMS	TRST*
8	GND	REF_CLK-	REF_CLK+	GND	AUX_CLK-	AUX_CLK+	GND

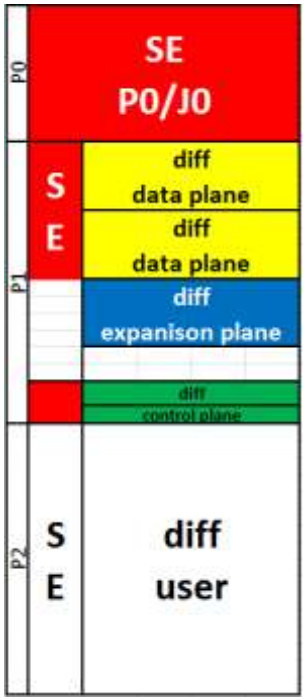


VNX

- Up to 32 Diff Pairs in S1
- Up to 18 Diff Pairs + 36 SE signals in S2
- **Total: 50 Diff Pairs + 36 SE**

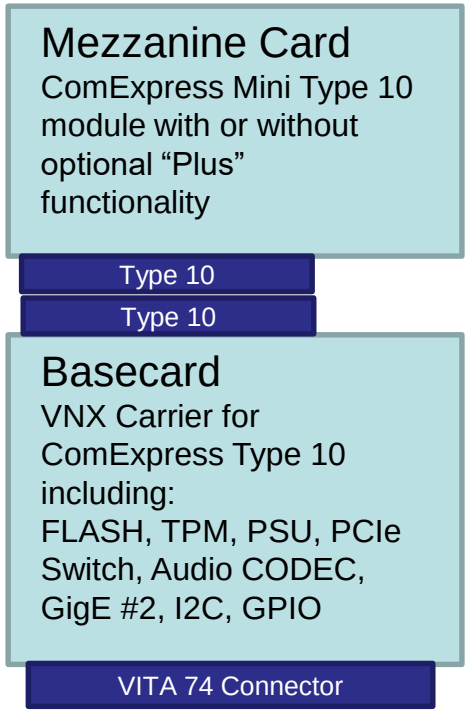
VPX

- Up to 32 Diff Pairs + 16 SE signals on P1
- Up to 32 Diff Pairs + 16 SE signals on P2
- **Total: 64 Diff Pairs + 32 SE**



VNX SBC Simplified Concepts

- **SBC utilizes VNX COM Express Mini Type 10 or Similar Standard Interface Scheme**
- **Carrier basecard has overhead circuitry including**
  - Power Supplies
  - FLASH Storage
  - Trusted Platform Module
  - PCIe Switch (With optional Ring Topology)
  - 2nd GigE Port
  - Hardware CODECs
  - ADC / DAC
  - SoM (ComExpress Mini Type 10) Connector
- **Processor Architectures**
  - Intel Architecture (Atom)
  - NXP Power Architecture
  - ARM
  - NVIDIA TX2 & Other GPGPU
  - Altera & Xilinx FPGA


Mezzanine Card
ComExpress Mini Type 10 module with or without optional “Plus” functionality
Type 10
Type 10
Basecard
VNX Carrier for ComExpress Type 10 including:
FLASH, TPM, PSU, PCIe Switch, Audio CODEC, GigE #2, I2C, GPIO
VITA 74 Connector

VNX Computer Module Mechanical Design

- Improved mechanical cover and heat frame design for maximized thermal efficiency
- Three piece mechanical design is more structural than extruded reference design
  - Allows for use in chassis with Wedgelocks per future VNX “dot spec”
  - More suitable for high power SBC and FPGA modules
- **All components on both sides of both boards are able to make direct contact with structural components of significant thermal mass for improved heat sinking capability**

Complete 19mm VNX Module

Top Cover Removed with Type 10+ SBC Exposed

Carrier and Center Heat Frame

Bottom Cover with Exposed Carrier

VNX Cross-Band Repeater Module Mechanical Design

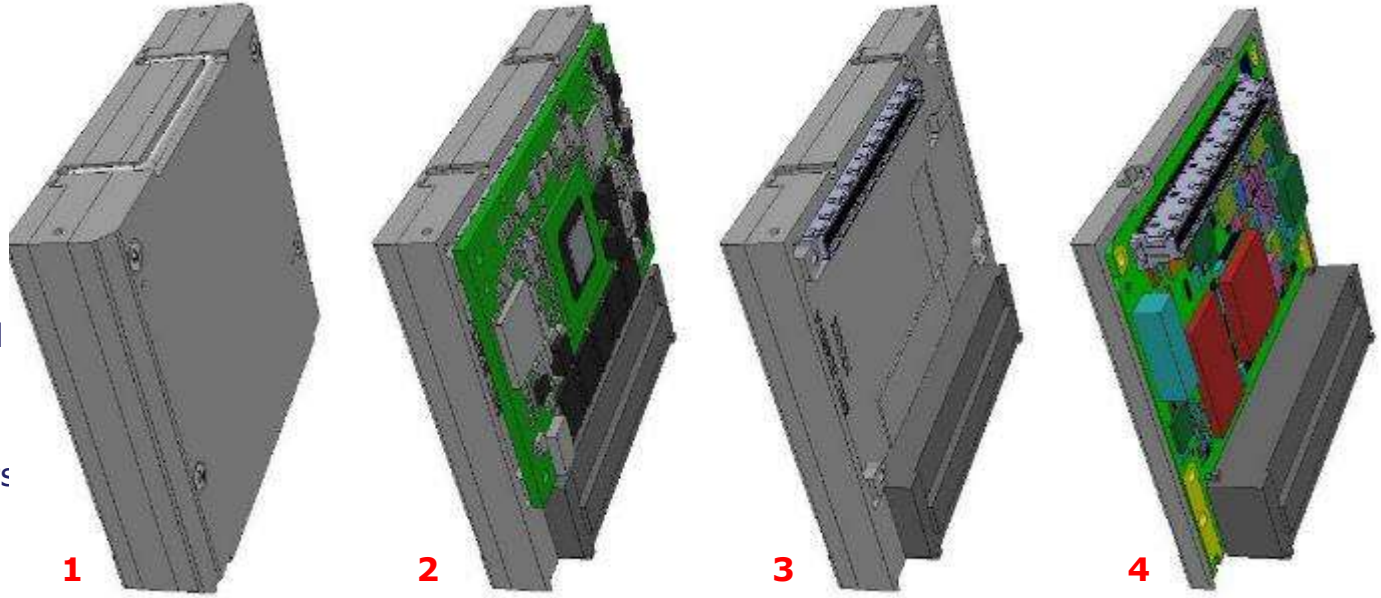
1 Complete Module (Left)

2 Top Cover removed.
Controller Visible

3 Controller removed

4 Middle Heat Frame removed.
Radio Modules Exposed

5 Board Stack Shown
Without Thermal Covers



Note: CAD Drawing shown are not Representative of actual CubeSAT Repeater Design, but are illustrative and for discussion only. Module is actually depicting an actual Single Board Computer.

VNX Computer Module
Typical SBC Slot Profile

S2 Signals

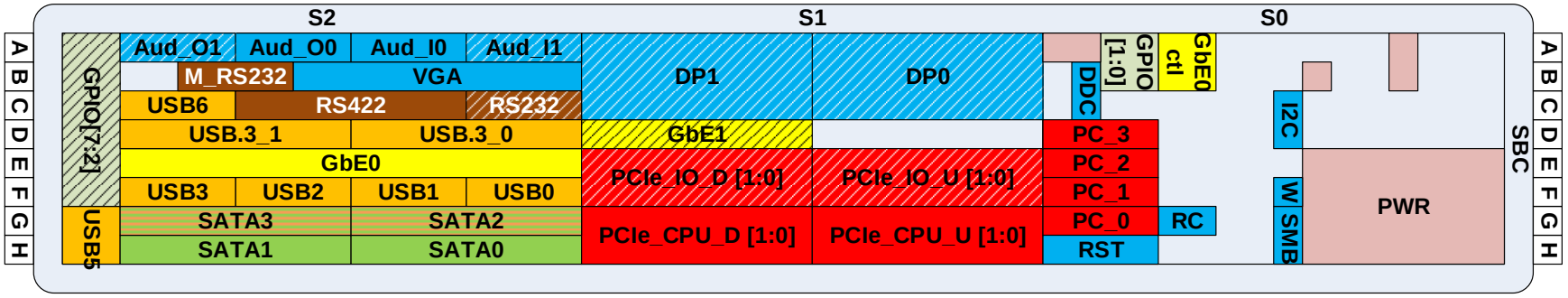
- 2x Audio In (L-R), 4x SE
- 2x Audio Out (L-R), 4x SE
- 2x RS-232 TTL
- 1x RS-422 (0x)
- 2x USB 3.0
- 6x USB 2.0
- 4x SATA II (1x)

S1 Signals

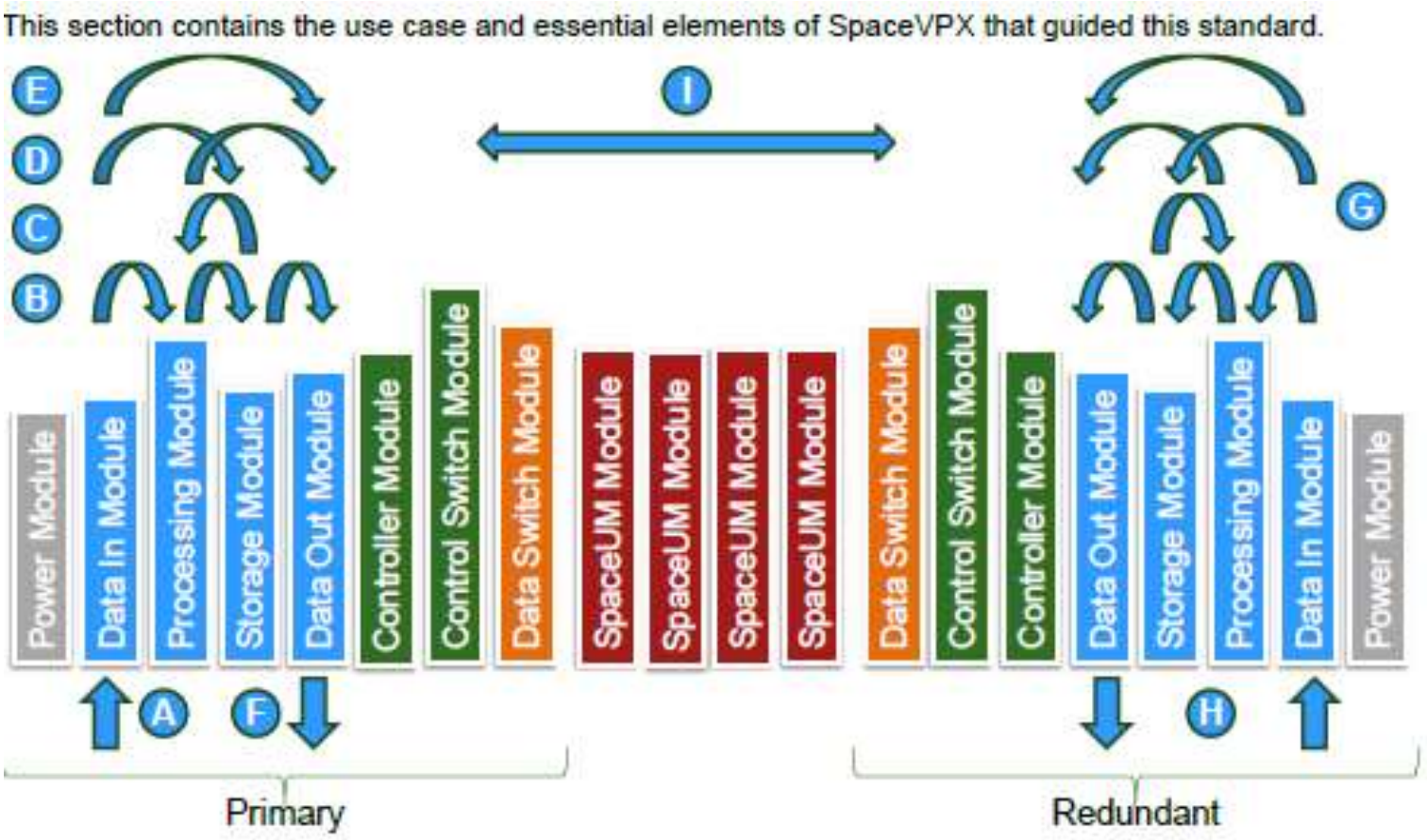
- 2x DP (Also LVDS, eDP)
- 8x PCIe (2x X2 Rings)
- 1x GigE
- 1x GigE (SerDes)
- 8x GPIO (SE)

S0 Signals

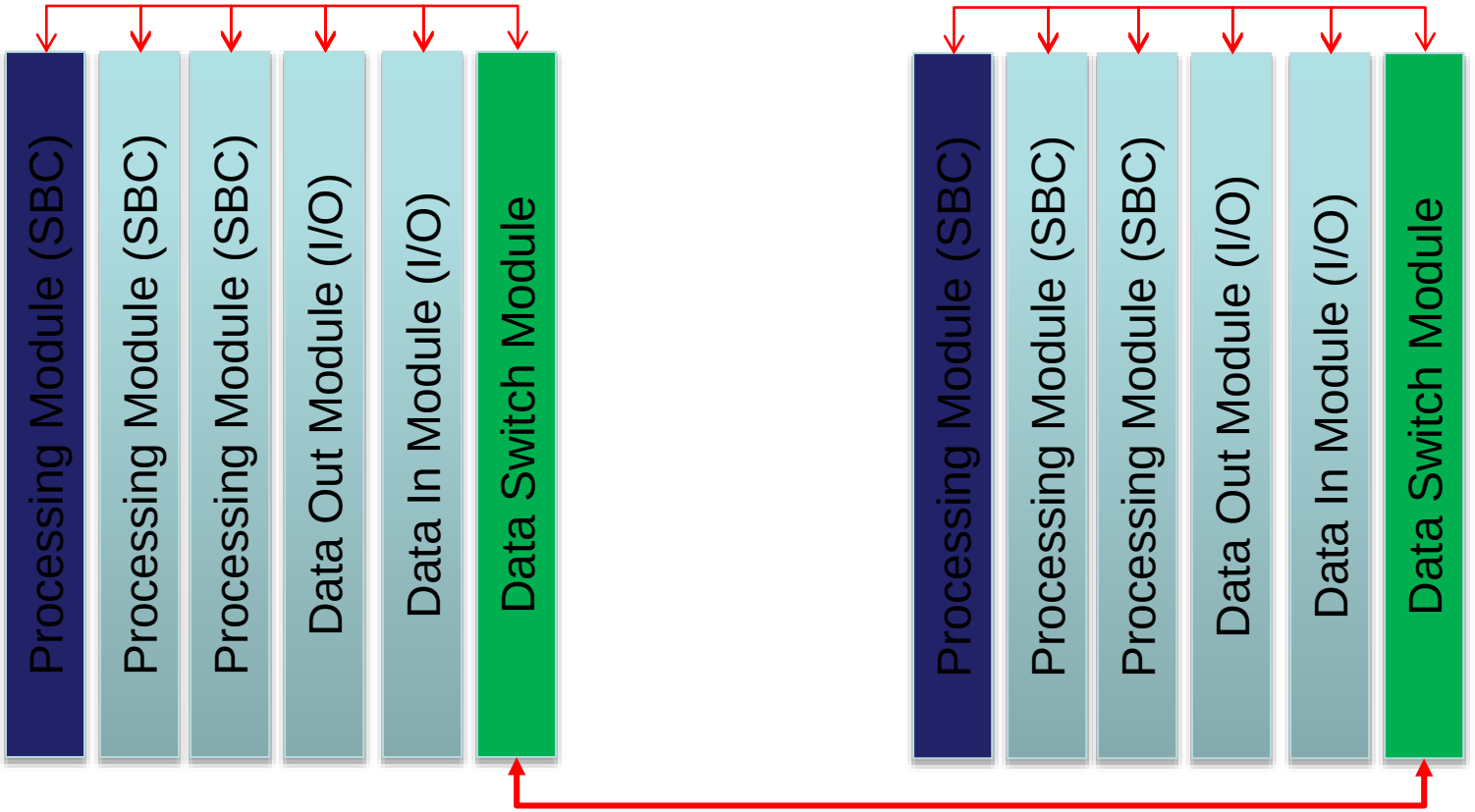
- RST
- 4x PCIe Clocks
- 1x I2C
- 1x SMB
- 1x WDT
- 1x RC



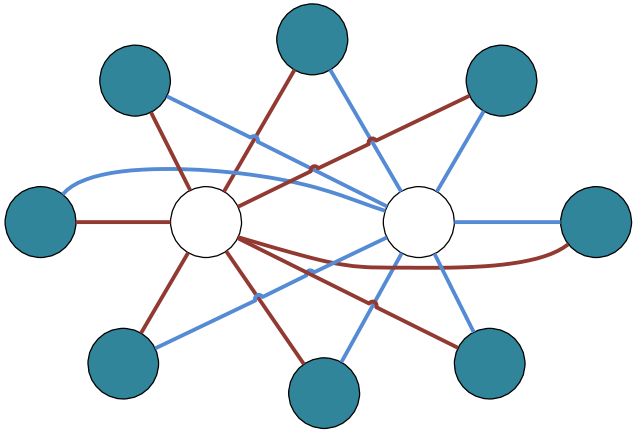
SpaceVPX Base Functional Use Case



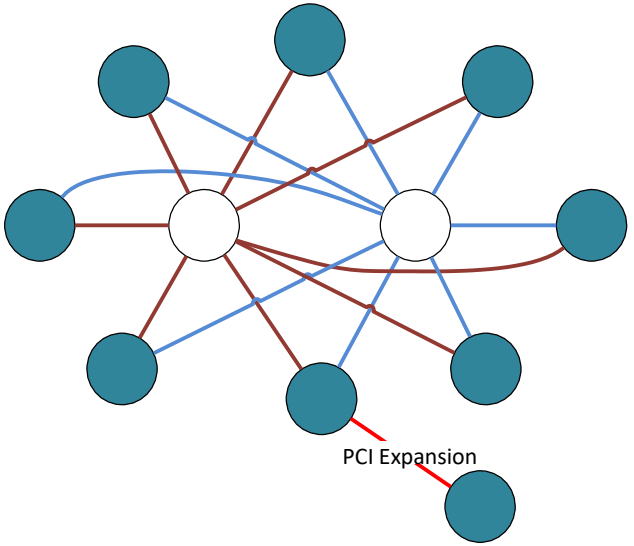
SpaceVNX Base Use Case



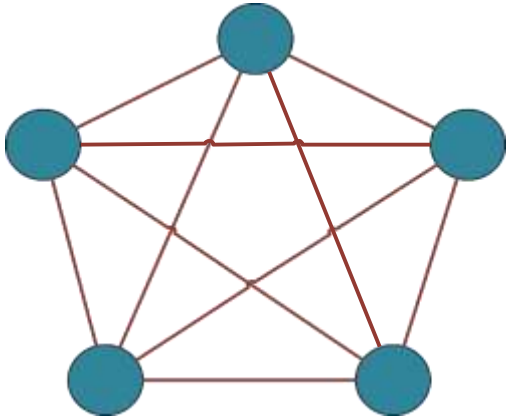
SpaceVPX Physical Topologies



Dual-Star Topology using two Switch Slots



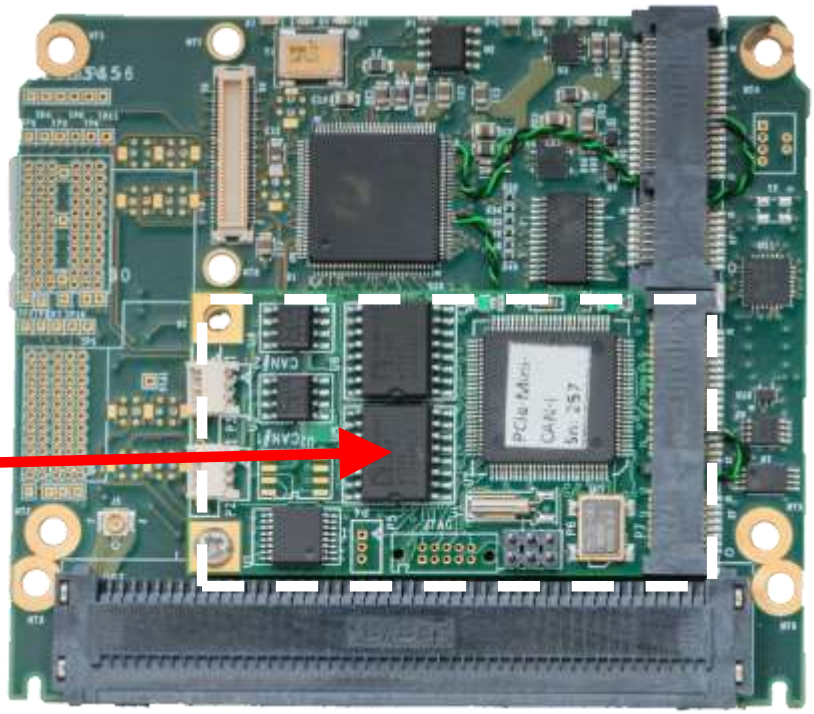
Dual-Star Topology with PCI Expansion



Full Mesh Topology

VNX Dual MiniPCIe Carrier Module

- VNX Module for 2x MiniPCIe Cards
- PCIe X1 or USB Control
- 12.5 mm Pitch
- Use with multiple MiniPCIe Modules from Multiple Suppliers
  - CAN Bus / MIL-STD-1553 / ARINC 429
  - Discrete / Analog
  - Serial / USB 3.0 / MIPI
  - Firewire / FiberChannel
  - GigE
  - FPGA Processors
  - Etc

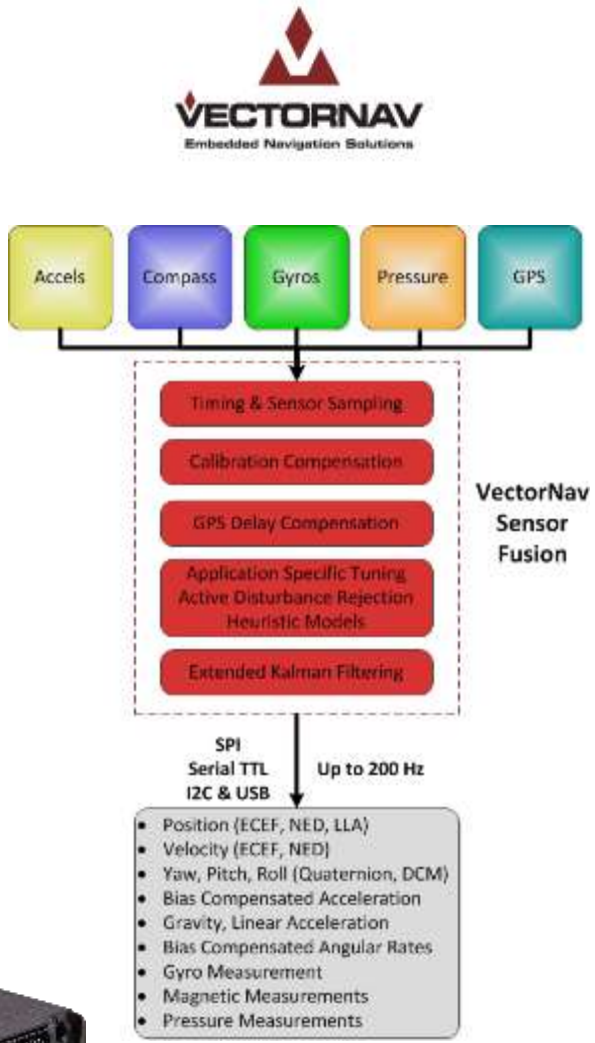


- Prototype with COTS, Build What you Need

VNX 12.5 mm Module

VNX IMU / GPS / SAASM Module

- AHRS
  - Real-Time Sensor Bias Compensation
  - Active Filter Tuning
  - Disturbance Rejection Algorithms
  - Individually Calibrated Sensors
  - Filtered Position, Velocity& Attitude at 200 Hz
- Additional Sensors & Processing
  - Barometric Pressure Sensor
  - Commercial GPS Receiver
  - Onboard Extended Kalman Filter Fusing GPS and Pressure Sensors with Accelerometers, Gyros, Magnetometers
  - Compatible with External GPS, SAASM, Pressure, and Magnetometer



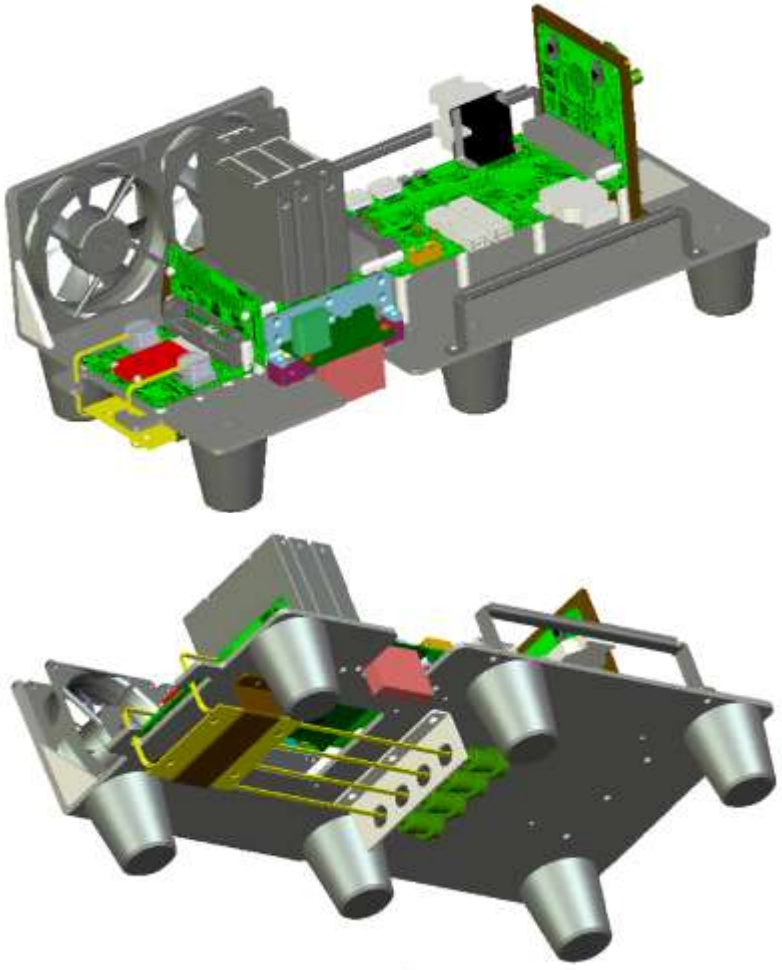
VNX 12.5 mm Module

VNX 2+2 Reference Platform Development Chassis

- VNX 2+2 Chassis
  - 2x 19.0 mm
  - 2x 12.5 mm

- Typical Card Set
  - 1x Compute & Control
  - 1x Sensor I/O
  - 1x Repeater / Telemetry
  - 1x IMU / GPS or Other I/O
  - Room for More Modules and Power Supplies

Typical VNX Development Platform



Courtesy of Mercury Computers

- Configured to be able to uses all the same modules as the rugged VNX System
- Provides Signal Monitoring module that allows for signal monitoring and connectivity with or without IOTB
- Allows for use without rugged PSU

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Thank You !

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